Angela Palmer is also responsible for the Ghost Forest installation, which was displayed in Copenhagen, London, and Oxford, and which recently moved to its final resting place at the National Botanic Garden of Wales at Llanarthne, Carmarthenshire. It includes ten large tree stumps from a commercially logged rainforest in West Africa. The trees are meant to draw attention to the alarming loss of natural resources and especially of the rainforests.

They were exhibited in Copenhagen during the climate change conference in December 2009, then spent two years on display outside Oxford's University Museum, where they attracted prominent visitors including Michelle Obama. In July 2012, they were moved to Wales, where they rest on the ground next to Norman Foster's Great Glasshouse and will be allowed to decay naturally over time. Their final move, a massive logistical challenge, was funded by Size of Wales, a charity that aims to conserve an area of tropical rainforest the size of Wales.

Thus, by representing, using, and incorporating biology, art can hopefully help to create awareness of and preserve the richness of life on our planet. Another poignant example of art turning fleeting manifestations of biology into permanent works is provided by the US artist Anthony Michael Simon, who in 2009 moved from Chicago to rural South Korea, in order to find inspiration from a different kind of environment.

In a kind of artistic dialogue with Nature, Simon started to highlight specific elements of plants, such as the leaves of a tree, by spray-painting them. After extending that approach to a gigantic spider web he had encountered during his tree-modifying excursions, he found out that he could encourage spiders he caught in the woods to spin their complex three-dimensional webs between three vertical Perspex rods in his study, rather than between trees. The artist then sprayed a protective coating on the webs, followed by bright colours. The resulting complex and colourful webs capture the fragility of life and the permanence of art, like the old saying, *ars longa, vita brevis*.

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Q & A

W. Tecumseh Fitch

Tecumseh Fitch is the head of the Department of Cognitive Biology at the University of Vienna. His research has followed two main paths: the evolution of cognition, and the bioacoustics of vocal production. He studies both topics from a broad comparative perspective. Initially trained in evolutionary and behavioral biology, he did a PhD in cognitive science at Brown University, after deciding to study language evolution from a biological perspective. He taught in both biology and psychology departments at Harvard and St Andrews before moving to Vienna in 2009 to co-found the new Department of Cognitive Biology, within the Life Sciences Faculty at the University of Vienna. *He has recently published a book* 'The Evolution of Language' *(CUP, 2010) and is a recipient of an ERC Advanced Grant. He has worked on a wide variety of species, including whooping cranes, deer, elephants, dogs and many primate species, and much of his work features direct experimental comparisons of such species with human beings.*

You've repeatedly switched among disciplines in your career: why? I got my start in behavioral biology and evolution, studying coral reef fish behavior in the Caribbean and the Red Sea, which was fascinating and great fun. Unfortunately, however, I have a weak stomach and got sea-sick one too many times, which led me to decide to continue my biological career on dry land. As part of this work I'd learned some Spanish and Hebrew and I became interested in language, and started reading people like Noam Chomsky and Philip Lieberman. The more I read, the more it seemed to me that the field, particularly in the case of language evolution, was overlooking some basic biological insights about evolution and neglecting the power of the comparative approach. So I decided to try to combine the study of animal communication and human language in a way that would be beneficial to both fields.

Because I knew next to nothing about language or psychology, I decided to do a PhD in Cognitive and Linguistic Sciences, in one of the first cognitive science PhD programs, at Brown University. That's when I started learning about acoustics and signal processing, and realized that insights from speech science could be applied to animal vocalizations (my PhD was about formant frequencies in non-human primates). After that, to learn more about acoustics, I did a post-doc in the Speech and Hearing Sciences program at MIT/Harvard, which had a strong engineering slant and gave me total freedom to take more courses in acoustics and speech science. Since then I've bounced back and forth between teaching in Biology and Psychology departments.

Despite all this disciplinary wandering, my perspective has remained biological, and I've remained focused on the broad set of issues surrounding the evolution of communication and cognition. In my opinion, the interesting scientific questions don't respect disciplinary boundaries, so neither should scientists who seek the answers. By now, I've collaborated and published with physicists, engineers, psychologists, linguists and computer scientists, and in every case have learned things of central relevance to the fundamental biological questions I'm interested in.

What is your view of the relationship between psychology and biology? I think things are in flux. In the days of Charles Darwin or William James there was little distinction made between biology and psychology, and both of these scholars moved flexibly between these topics. But today the two fields have diverged almost completely, to the detriment of both. The biggest issue right now is that the cognitive revolution happened in human psychology, and by 1980 it became acceptable again to use mentalistic theories and explanations — in humans. But in animal cognition and neuroscience, such explanations are still viewed suspiciously, and many people still only accept cognitive explanations if all possible associationist or behavioristic explanations, however complex and post-hoc, can be clearly ruled out. Although things are changing, I think

this situation leads to real problems in trying to build evolutionary bridges between animal cognition and communication and human cognition. The cognitive revolution remains incomplete.

The new field of evolutionary psychology is a step in the right direction, trying to move psychology towards a more biological grounding. Unfortunately, this field is dominated by psychologists focused almost exclusively on human psychology, and so lacks the strong comparative perspective that typified Darwin or the great ethologists like Tinbergen and Lorenz. Also, they've been very focused on adaptive explanations, and have paid less attention to mechanistic and developmental questions, or to the role of phylogenetic constraints in evolutionary explanations. In cognitive biology we hope to remedy this by fusing the broad comparative biological perspective of ethology and animal behavior with modern cognitive and computational perspectives on mind (whether in humans or other animals).

How did you end up in Vienna? The main draw was the opportunity to create a new department with two like-minded colleagues, Thomas Bugnyar and Ludwig Huber. Both share an ethological mindset and appreciation of a broad comparative approach, but they use different study species and have different research areas, so there has been a real synergy of interests and topics. Besides creating a new department dedicated to cognitive biology, we've combined forces to create a fantastic and unique research station south of Vienna, with ravens, keas and a big bioacoustics lab. There are also lots of great colleagues in Vienna in biology, psychology and other disciplines, and the University of Vienna has been very supportive of our efforts to do inter-disciplinary research. And as a place to live Vienna is fantastic, with an extremely high quality of life and great arts, music and museums. So despite occasionally missing the U.S. and Scotland, I'm very happy I ended up in Vienna.

You've done a lot of work on the evolution of language: where does linguistics fit into this discipline? I think that, in principle, linguistics should play a central role in cognitive science generally, and in studying language evolution in particular. Language is, by far, the best understood cognitive system we have, and linguists have amassed an enormous knowledge and understanding of many phenomena (though there's lots left to learn, of course). Unfortunately, contemporary linguistics is very fragmented, with many 'schools of grammar' that barely speak to or cite one another (bearing opaque names and acronyms like minimalism, construction grammar, CCG, GPSG, LFG, RRG and so on). Even though I think there is a lot of common ground between these linguistic approaches, they tend to focus on the differences, and this makes it quite difficult for an outsider to get the big picture. There is also an unfortunate tendency for both linguists and those in other fields to try to score points by bashing Noam Chomsky, often freely employing ludicrous caricatures and spurious arguments. So in general I don't think linguistics is currently fulfilling its potential promise as a flagship discipline in the cognitive sciences, and that linguists themselves are partly to blame for this.

What are your views about journals, reviewing and open access? Like all academics I've provided an immense amount of free labor to journals as a reviewer and editor, with no tangible reward. We do it out of a feeling of obligation to science itself. Simultaneously, I am frustrated on a daily basis by lack of access to published research. Given that academics do virtually all the work of publishing these days, writing, typing, reviewing, editing and copy-editing their papers, while the profits go mostly to a few big publishing houses and their investors, I think the current publishing-for-profit model is bound to break down eventually. It is based on an outmoded model from when typesetting and copy-editing were a lot of work, and printed paper was the only means of publication. The internet has changed all that, but our publishing model hasn't caught up yet. I think that publishers are going to have to find creative solutions that are more fair if they hope to survive. Paying to publish, granting free open access to all, is quite sensible in many disciplines, and for people who have solid grant support, but it isn't a complete solution. A few publishers grant online journal access in return for reviewing, and I think that should be a minimum reward. I also think that publishing reviews is a good idea in many cases: it would constitute a publication and keep reviewers civil and honest. Overall, I expect big changes and a continued move to open access in the coming decade.

You spent some time in Marc Hauser's lab in the 1990s — what is your opinion of the Hauser scientific misconduct affair? I was disappointed and distressed that the final report from the US Office of Research Integrity remained vague, and left open whether there was any intentional falsification. In my time in Hauser's lab, I was very impressed by Marc's energy and intellectual breadth, and although his methods sometimes seemed careless I never saw anything smacking of intentional falsification or manipulation of data. Now there are all these accusations from unnamed people in the press, but after years of investigation the final report neither confirms nor denies the crucial accusations.

In any case, I think the broader message of the whole Hauser saga is to underscore the central importance of *replication* in biology. Physicists, chemists and doctors replicate all the time — it is part of the culture — but psychologists and behavioral biologists rarely do so (partly because you can't get funded to replicate, or publish the results). I think we need to develop a much stronger culture of replication, encouraging our students to replicate key studies, and urging editors and reviewers to publish replications or failures to replicate.

Do you have any advice for young scientists? Sure. First, I think all biologists, young or old, should learn computer programming (I recommend Python as a great language). Biology is becoming more and more data-driven, and the traditional biologist's education leaves most of us poorly-equipped to deal with the flood of data, whether in bioinformatics, bioacoustics, ecology or neuroscience. If biologists don't learn computing, physicists and engineers will get all the jobs

and take over the discipline. If we want to make sure that the biology of the future preserves our hard-won biological perspectives, knowledge and insights, we need to be able to do the analyses and deal with all these data ourselves.

For young scientists embarking on a PhD, make sure your PhD topic is something you love, and that your question is one whose answer you care deeply about. Don't settle for less than this, or you'll lack the drive needed to work to your own full potential. And if there's some body of knowledge or theory that is important to your question, whatever the discipline, just roll up your sleeves and learn it. For post-docs, one word: 'publish!' And don't spend months trying to get a paper perfect in every detail before submitting: your reviewers will find flaws no matter what. Spend your time getting the experiments and analysis right, not perfecting the writing.

Your website says you play music and paint: does science influence your creative work? While in college I seriously considered a career in the arts, and many of my closest friends and band-mates went on to become professional musicians. I've played in rock and salsa bands and an African drumming ensemble, and I still play a lot of guitar and write and record songs. And recently, we've been studying the biology and evolution of music, and I've really been enjoying the opportunity to combine music with scientific research.

Regarding the influence of science, I draw the figures for a lot of my publications (ink drawings or watercolors, reworked with Adobe Illustrator). I've also written some biological songs, including "*I Don't Believe in Evolution*", which pokes fun at creationists and has been live-broadcast on Italian radio (and even served as a ring tone on some of my students' phones!).

But frankly, I'm happy to have science as my 'day job' and music and painting as hobbies: I think the pressure to make money with art would take the fun out of it.

So you're glad you became a scientist? Absolutely. I feel incredibly fortunate to be a scientist. Sure, scientists' salaries are not usually commensurate to their education and ability. But how many people are lucky enough to be paid to follow their interests and satisfy their own curiosity every day?

What are the most exciting topics you are researching right now? At the moment I'm very excited about our new research program in empirical aesthetics, trying to understand the biological roots of the visual arts, and in particular of the human love for symmetry and order. Humans around the planet surround themselves with decorative patterns, with no obvious function, such as weaving, quilting, decorated pottery, clothes, tattoos and architectural ornament. Oddly, art historians have largely focused on representational art by great geniuses, and neglected this much more widespread, popular and presumably ancient form of art (often relegated to 'craft'). We've been bringing ordinary people into the lab and studying the kinds of patterns they make using computer interfaces (as well as what they like, and what kind of rules they can perceive). It looks like there is a deep biological drive in our species — what the art historian Ernst Gombrich called our 'sense of order' — that hasn't received enough attention.

I'm also very excited about our work in bioacoustics, trying to understand how animals produce their sounds. This is a truly inter-disciplinary bridging area, spanning an amazing breadth of disciplines from physics to physiology to behavior, cognition, and evolution. It also relies on comparative anatomy, so you get to dig out old anatomical papers documenting weird and wonderful adaptations for sound production that were forgotten long ago, and then try to understand them from the viewpoint of modern acoustics and nonlinear dynamics. We're studying vocal production in alligators, deer, primates, ravens, parrots, and lots of other species, but it is amazing how the same physical phenomena and principles (mostly originally discovered in human speech) seem to underlie all this diversity. It's a comparative biologist's dream come true.

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Quick guide

Aquaporins

A.S. Verkman

What are aquaporins? Aquaporins (often called aquaporin water channels) are a family of small, integral membrane proteins that are expressed broadly throughout the animal and plant kingdoms. They have a similar basic structure, with aquaporin monomers consisting of six transmembrane helical segments and two short helical segments that surround cytoplasmic and extracellular vestibules connected by a narrow aqueous pore (Figure 1A). They contain several conserved motifs, including NPA sequences in their short helical segments. Aquaporin monomers assemble as tetramers in membranes, with each monomer functioning independently. Some aquaporins, such as mammalian AQP4, can further aggregate in cell membranes to form supramolecular crystalline assemblies called orthogonal arrays of particles.

What do aquaporins do at the molecular level? The primary function of most aquaporins is to transport water across cell membranes in response to osmotic gradients created by active solute transport. Because the water transport capacity of aquaporin monomers is low, membranes often contain a high density of aquaporins, up to 10,000 per square micron, to increase water permeability substantially above that in the absence of aquaporins. Molecular dynamics simulations suggest that steric factors and electrostatic interactions in the aqueous pore are responsible for the selectivity of aquaporins for water. A subset of aquaporins, called aquaglyceroporins also transport glycerol. The pore diameter of the aquaglyceroporins is slightly greater than that of the water-selective aquaporins, and the pore is lined by relatively hydrophobic residues compared with the pore of a water-selective aquaporin. In addition to water and glycerol, there is evidence, some of which is controversial, that some aquaporins pass gases (CO_2, NH_3, NO, O_2), various small solutes such as H_2O_2 and arsenite, and